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coefficients are seminvariants, and the process explained in my memoir on the Equation of Differences was therefore applicable, and by means of it, the equation is readily obtained. The auxiliary equation gives rise to a corresponding covariant equation, which is given at the conclusion of the memoir.

III. "On Combustion in Rarefied Air." By Dr. EDWARD FRANKLAND, F.R.S. Received February 28, 1861.

In the autumn of 1859, whilst accompanying Dr. Tyndall to the summit of Mont Blanc, I undertook at his request some experiments on the effect of atmospheric pressure upon the amount of combustible matter consumed by a common candle. I found that, taking the average of five experiments, a stearin candle diminished in weight 9·4 grammes when burnt for an hour at Chamounix; whilst its ignition for the same length of time on the summit of Mont Blanc, perfectly protected from currents of air, reduced its weight to the extent of 9·2 grammes.

This close approximation to the former number under such a widely different atmospheric pressure,* goes far to prove that the rate of combustion is entirely independent of the density of the atmosphere.

It is impossible to repeat these determinations in a satisfactory manner with artificially rarefied atmospheres, owing to the heating of the apparatus which surrounds the candle, and the consequent guttering and unequal combustion of the latter; but an experiment in which a sperm candle was burnt first in air under a pressure of 28·7 inches of mercury, and then in air at 9 inches pressure, other conditions being as similar as possible in the two experiments, the consumption of sperm was found to be,—

At pressure of 28·7 inches 7·85 grms. of sperm per hour,

 " 9·0 " 9·10 " "

thus confirming, for higher degrees of rarefaction, the result previously obtained.

In burning the candles upon the summit of Mont Blanc, I was much struck by the comparatively small amount of light which they emitted. The lower and blue portion of the flame, which under

ordinary circumstances scarcely rises to within a quarter of an inch of the apex of the wick, now extended to the height of $\frac{1}{8}$ th of an inch above the cotton, thus greatly reducing the size of the luminous portion of the flame.

On returning to England, I repeated the experiments under circumstances which enabled me to ascertain, by photometrical measurements, the extent of this loss of illuminating effect in rarefied air. The results prove that a great reduction in the illuminating power of a candle ensues when the candle is transferred from air at the ordinary atmospheric pressure to rarefied air. It was, however, found that, owing to the circumstances mentioned above, no satisfactory quantitative experiments could be made with candles in artificially rarefied air, and recourse was therefore had to coal-gas, which, although also liable to certain disturbing influences, yet yielded results, during an extensive series of experiments, exhibiting sufficient uniformity to render them worthy of confidence. The gas was in all cases passed through a governor to secure uniformity of pressure in the delivery tubes. A single jet of gas was employed as the standard of comparison, and this was fixed at one end of a Bunsen's photometer, whilst the flame to be submitted to various pressures, and which I will call the experimental flame, was placed at the other. The experimental flame was made to burn a uniform amount of gas, viz. 0.65 cubic foot per hour in all the experiments.

The products of combustion were completely removed, so that the experimental flame, which burnt with perfect steadiness, was always surrounded with pure air, the supply of which was, however, so regulated as to secure a maximum of illuminating effect in each observation.

In all the following series of experiments, the illuminating power given under each pressure is the average of twenty observations, which accord with each other very closely. In each series, the maximum illuminating effect, that is the light given by the experimental flame when burning under the full atmospheric pressure, is assumed to be 100. The following is a summary of the results:—

1st Series.

Pressure of air in inches of mercury.	Illuminating power of experimental flame.
29·9	100·
24·9	75·0
19·9	52·9
14·6	20·2
9·6	5·4
6·6	·9
2nd Series.	
30·2	100·
28·2	91·4
26·2	80·6
24·2	73·0
22·2	61·4
20·2	47·8
18·2	37·4
16·2	29·4
14·2	19·8
12·2	12·5
10·2	3·6

These numbers indicate that even the natural oscillations of atmospheric pressure must produce a considerable variation in the amount of light emitted by gas-flames, and it was therefore important to determine, by a special series of observations, this variation in luminosity within, or nearly within, the usual fluctuations of the barometrical column. In order to attain greater delicacy in the pressure readings in these experiments, a water-gauge was used, but its indications are translated into inches of mercury in the following tabulated results, each of which represents, as before, the average of twenty observations.

3rd Series.

Pr. of air in in. of mercury.	Illum. power of exp. flame.
30·2	100·
29·2	95·0
28·2	89·7
27·2	84·4

It is thus evident that the combustion of an amount of gas which would give a light equal to 100 candles when the barometer stands at 31 inches, would give a light equal to only 84·4 candles if the barometer fell to 28 inches.

An inspection of all the above results shows that the rarefaction of air, from atmospheric pressure downwards, produces a uniformly diminishing illuminating power until the pressure is reduced to about 14 inches of mercury, below which the diminution of light proceeds at a less rapid rate. The above determinations give approximately 5·1 per cent. as the mean reduction of light for each diminution of 1 inch of mercurial pressure down to 14 inches. The following Table exhibits the actually observed light, compared with that calculated from this constant.

1st Series.

Pressure.	Illuminating power.	
	Observed.	Calculated.
29·9	100·	100·
24·9	75·0	74·5
19·9	52·9	49·0
14·6	20·2	22·0
9·6	5·4	— 3·5
6·6	·9	— 18·8
2nd Series.		
30·2	100·	100·
28·2	91·4	89·8
26·2	80·6	79·6
24·2	73·0	69·4
22·2	61·4	59·2
20·2	47·8	49·0
18·2	37·4	38·8
16·2	29·4	28·6
14·2	19·8	18·4
12·2	12·5	8·2
10·2	3·6	— 2·0
3rd Series.		
30·2	100·	100·
29·2	95·0	94·9
28·2	89·7	89·8
27·2	84·4	84·7

I am now extending this inquiry to pressures exceeding that of the atmosphere, and hope soon to lay before the Society the detailed results of the whole series, together with some observations on the causes of this variation of luminosity.